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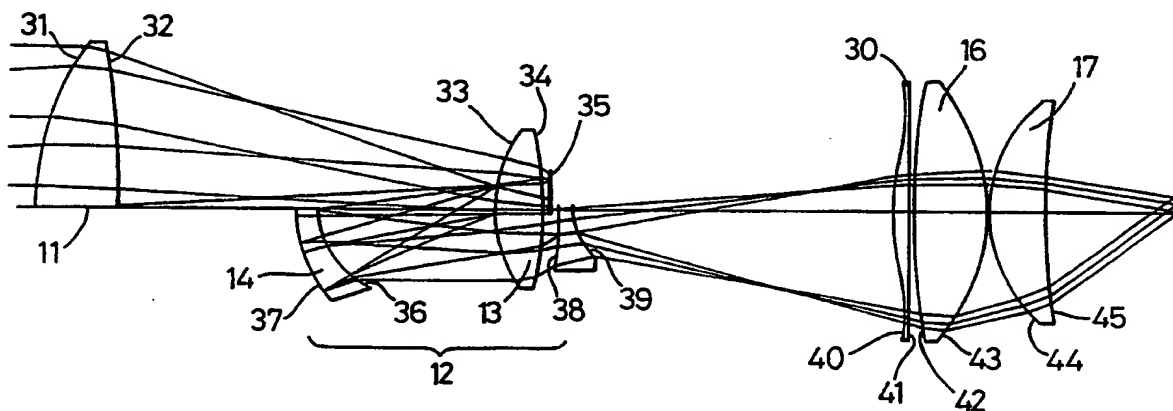
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| | | |
|---|-----------|--|
| (51) International Patent Classification 5 : G02B 17/08, 23/02, 17/00 | A1 | (11) International Publication Number: WO 94/06047 (43) International Publication Date: 17 March 1994 (17.03.94) |
| (21) International Application Number: PCT/EP93/02297 (22) International Filing Date: 26 August 1993 (26.08.93) (30) Priority data: 9218325.0 28 August 1992 (28.08.92) GB 9219559.3 16 September 1992 (16.09.92) GB (71) Applicant (for all designated States except US): OPTICS & VISION LIMITED [GB/GB]; 70 Vale Street, Denbigh, Clwyd LL16 3BW (GB). (72) Inventor; and (75) Inventor/Applicant (for US only) : FREEMAN, Michael, Harold [GB/GB]; Optics & Vision Limited, 70 Vale Street, Denbigh, Clwyd LL16 3BW (GB). (74) Agent: LIVESLEY, John, Ronald; 6 Pinehurst Road, Liverpool L4 2TY (GB). | | (81) Designated States: AU, BG, CA, JP, KR, RU, US, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE). Published <i>With international search report.</i> |

(54) Title: OPTICAL SYSTEM ESPECIALLY FOR BINOCULARS AND OTHER VIEWING INSTRUMENTS**(57) Abstract**

An optical system as described in British Patent Application 2249406A using inverting mirrors has the inverting mirrors (13 and 14) disposed in a central unit that is with the mirror (14) disposed between the objective (11) and the first mirror (13). The application also describes a novel baffling system wherein the useful light near the axis of the system passes through a polarising screen (19), a retardation plate (24) twice, and another polarising screen (20) whilst stray light will bypass the retardation plate and be cut out by the cooperation of the two screens. The application also describes a binoculars-camera combination wherein a reflex type mirror (7) and a collimating lens unit (10) passes substantially collimated light to a camera (11).

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OPTICAL SYSTEM ESPECIALLY FOR BINOCULARS AND OTHER
VIEWING INSTRUMENTS

FIELD OF THE INVENTION

The present invention relates to an optical system
5 for use with a plurality of inverting mirrors as in British
Patent Application 22494406A.

BACKGROUND OF THE PRESENT INVENTION

In our British Patent Application 22494406, we
describe an optical system using inverting mirrors. The
10 present invention aims at an improvement to that design.

SUMMARY OF THE PRESENT INVENTION

The present invention provides an optical system using
inverting mirrors wherein the second inverting mirror is
disposed behind the objective between that objective and
15 the first inverting mirror.

By so disposing the second mirror, the second mirror can
be smaller than hitherto. Whilst it becomes more difficult to
to build in optical corrections to the design, an acceptable
optical quality can still be obtained; moreover due to the
20 smaller size of this second mirror it is cheaper to build
in optical corrections to a smaller mirror.

The great advantage of the smaller mirror is that the
mirror is cheaper and the casing of the optical system can
also be smaller reducing the bulk and weight of the entire
25 instrument.

It is possible to use a relatively simple objective lens
system and a relatively simple eye piece unit which can be
made large to capture more light and/or display a wider
field without incurring the high cost and weight associated
30 with more complicated lens assemblies. Instead the
complications are all dealt with in the inverting mirrors.
If the mirror is a Mangin-type lens it is possible to silver
only part of the lens material so the upper part can act as
a straightforward lens with usually negative power and co-
35 operate with an objective lens to form a telephoto type
objective. This would allow the original objective to be
further back so as to give a shorter instrument and/or one
with better optical correction.

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It is possible to use the inverting mirrors as a unit to focus the instrument by altering the spacing of the two mirrors and since only a short movement would be required electro-mechanical materials could be used lending itself to push button focussing.

The advantages of this design stem from concentrating the complexity of the optical design into the two inverting mirrors in a central region of the system where the light bundle is smaller and thus the mirrors can be smaller. At the objective, the light bundle is large to maximise the aperture of the instrument even though the field angle is small. At the eye piece the lens size needs to be large if a large field angle and eye relief distance is to be obtained even though the aperture of each ray bundle is small. In this new concept, the ray bundle size and field angle value are both modest in the central region and the components in this region are therefore of modest size. This means they can be more complex without becoming very heavy and expensive. The large components of the objective and the eyepiece can then be simple so that even though they are of larger diameter their cost and weight is relatively low. This contrasts favourably with conventional binoculars and other optical systems where the optical paths are folded by prisms which merely correct image orientation and all optical correction has to be done at the objective or eyepiece. The necessary complexity of the central components in the present invention is naturally dependent on the quality of the optical correction required of the instrument and on the length of the central unit itself. Good correction can be found with the ratio between the overall length of the central unit and the diameters of its components between 4:1 and 1.2:1 approximately.

When the magnification of the instrument is increased the objective lens will probably be of larger diameter and larger focal length. This will place the objective further in front of the central optical unit. Compared to the preferred construction described in British Patent 2294406A, the location of the front Mangin mirror is dictated more by the

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rear Mangin mirror and not by the objective.

Another aspect of the present invention provides an optical system using inverting mirrors wherein the light paths are separated from each other by the use of polarising
5 screens.

Using conventional light baffles it is possible for light to bypass the central optical components and to pass direct to the eye piece. The polarising screens can be larger than conventional light baffles and so ensure that
10 light cannot bypass the central optical unit and go direct to the eyepiece. Useful light passing through the polarising screens can be utilised.

The present invention has particular relevance to binoculars and spotting scopes.

15 BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 illustrates one form of optical system according to the present invention,

Figure 2 illustrates a second form of optical system according to the present invention,

20 Figure 3 illustrates a further modification identifying various surfaces, and

Figure 4 illustrates a further form of optical system according to the present invention.

DESCRIPTION OF EXEMPLARY EMBODIMENTS

25 Figure 1 illustrates an optical system wherein light passes through an objective lens 11 to an inverting mirror system 12 consisting of a first Mangin-type mirror 13, a second Mangin-type mirror 14 and a lens array formed by the, unsilvered lower half of the mirror 13 and a further lens
30 15. From the lenses 13 and 15, the light passes to an eye-piece unit formed by lenses 16 and 17.

In Figure 2, the construction is similar and the same reference numerals are used. The difference is that the upper half of the second mirror is also unsilvered and
35 projects into the optical path between the objective lens and the first mirror and so co-operates with the objective lens to form a telephoto-type lens. If the effect of this upper half is of a negative power lens, the objective can

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be moved to the right and thus make a shorter instrument or remain at a similar distance and form a better corrected instrument.

5 In both these embodiments, the two inverting mirrors are in a central region of the system wherein the light-bundle is concentrated. Good correction of optical defects can be obtained if the overall length of the central unit formed by the Mangin mirrors is about 1.2 to 4 times the diameter of its components.

10 Both of the above Figures are suitable for giving a X 8 magnification but the principles are applicable at any magnification particularly high magnifications such as X 20 and X 40 as used in spotting scopes.

15 In both Figures, means (not illustrated) can be provided to alter the spacing or location of the mirrors to focus the instrument.

In Figure 3, the arrangement is similar and the same reference numerals are used. There are two differences in construction namely a further lens 30 is used in the
20 eyepiece unit and the first Mangin lens does not use silvering of a lens to form the actual mirror but uses a separate mirror 35 which can be formed by silvering a separate plastics material component. By using this separate component, the lens can be of simple design and
25 any asphericity can be moulded into the separate component. The component can also be light and so can be moved easily with little power to focus the instrument. This embodiment is for a 10 X 25/35 design providing a magnification of 9.7 X with eye relief of 18 millimetres. The objective is
30 semicircular with a diameter of 27 millimetres which may be truncated to give an oval aperture of 25 millimetres by 35 millimetres. The horizontal field of view is well corrected up to 8° or 9° and has a maximum value of 10° or thereabouts; this is equivalent to more than 95° at
35 the eye.

The following table gives the main dimensions and properties of the optical components.

WO 94/06047

PCT/EP93/02297

| | SURFACE NUMBER | RADIUS OF CURVATURE (mm) | - 5 - AXIAL SEPARATION (mm) | REFRACTIVE INDEX | V-VALUE (CONSTRINGENCE) |
|----|-------------------|--------------------------------|--------------------------------------|---------------------|----------------------------|
| 5 | 31 | 43.76 A | | | |
| | 32 | -146.69 A | 11.87 | 1.492 | 57.45 |
| | 33 | 25.14 | 51.62 | | |
| 10 | 34 | -69.77 | 6.60 | 1.846 | 23.83 |
| | 35 | 71.87 MA | 0.90 | | |
| | 36 | 15.99 | -31.50 | | MIRROR |
| 15 | 37 | 25.29 M | | | |
| | 38 | -70.84 | 30.00 | | |
| | 39 | 11.14 | 1.80 | 1.744 | 44.72 |
| 20 | 40 | 33.04 | 44.31 | | |
| | 41 | PLANE | 2.40 | 1.492 | 57.45 |
| | 42 | 126.21 | 0.60 | | |
| 25 | 43 | -35.59 | 10.27 | 1.713 | 53.83 |
| | 44 | 25.93 | 0.15 | | |
| | 45 | 150.00 | 7.86 | 1.713 | 53.83 |

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(A)

ASPHERIC SURFACES

| | SURFACE RADIUS OF CONIC | | | ASPHERIC COEFFICIENTS | | |
|---|-------------------------|-----------|----------|-----------------------|-----------|------------|
| | NUMBER | CURVATURE | CONSTANT | A4 | A6 | A8 |
| 5 | 31 | 43.78 | -1.0 | -9.087E-8 | 4.276E-10 | 1.687E-13 |
| | 32 | -146.69 | -1.0 | 2.770E-7 | 7.709E-10 | -2.762E-13 |
| | 35 | 71.87 | 0.0 | 7.525E-7 | -5.775E-7 | 1.428E-8 |
| | 40 | 33.04 | -1.0 | -4.343E-5 | 5.824E-08 | -4.880E-11 |

(M)

- 10 REFLECTING SURFACES
- 35 FRONT SURFACE MIRROR
- 37 MANGIN-TYPE MIRROR

15 It would be possible to have the second mirror made with a pure reflective surface slightly behind a lens as well as or instead of the first mirror being made in this way. The advantages of making the second mirror in this way would be those described for the first mirror but do not seem quite as effective as for the first mirror.

20

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Figure 4 illustrates a novel baffling arrangement. Instead of the usual opaque baffles, a first polarising screen 19 acting somewhat like an oversize opaque baffle projects into the light passing through the objective from below. Most of the light will pass to the first mirror without going through this screen but light towards the bottom passes through the screen. A second screen 20 projects into the light path from above at the exit from the inverting system 12 or thereabouts and is polarised to intercept unwanted light passing straight from the objective to the eyepiece without passing through the mirrors. Some useful light will pass through the first screen 19 to the first mirror and then to the second mirror and this is saved by having a retarder plate 24 associated with the second mirror 14 so that light reflected from the first mirror after passing through the first screen will pass through the retarder plate which is designed to give a quarter wave length retardation on each pass; it will be appreciated that the light will pass through the plate not only on its way to the second mirror but will also pass through the plate after reflection by the second mirror. This useful light will thus be able to pass through the screen 20 with only an acceptable amount of attenuation whilst the unwanted light will be totally intercepted.

In all embodiments the light bundle or at least the inherently available light bundle is non-circular so that the light path can be folded tightly on itself.

In this specification, references to the first mirror means that mirror which is physically the back mirror but is the first mirror to reflect the light and the second mirror is in front physically of the back, first, mirror.

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A further aspect of the present invention concerns a combination of binoculars and a camera. The binoculars can be as those described earlier. In this embodiment, there is provided a binoculars-camera combination wherein
5 the binoculars are provided with a reflex-type mirror towards the exit point of the binoculars, which mirror when actuated reflecting the light sideways, and wherein the reflected light is substantially collimated either in the binoculars before reaching the said mirror or after
10 reflection by said mirror, and wherein the camera is mounted out-of-line of the binoculars to receive the collimated light.

Because the light it receives is collimated, the positioning of the camera is not crucial and the camera
15 lens does not have to be removed. The camera does not get in the way of normal use of the binoculars and indeed the binoculars can be used normally with only minor interruption by the use of the camera.

Figure 5 illustrates such a binoculars camera
20 combination.

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The drawing shows one of the optical paths in a pair of binoculars as described in U.K. Patent Specification 22494406A. There is an object lens 1 directing the light through a pair of inverting mirrors 2 and 3 and then to an eyepiece combination 4 and 5; between the parts 4 and 5 of said combination there are a pair of plane mirrors 6 and 7. In the present invention, the mirror 7 is adapted to serve as a kind of reflex mirror which in normal use in position 8 directs the light through the second part of the combination 4 and 5. When actuated the mirror moves to position 9 reflecting the light sideways into a collimating lens unit 10 similar to the part 5, which collimates the light prior to entry to a camera 11. The position 9 can be such that the camera axis is at right angles to the binocular axis or such that the camera is tilted further away from the users face.

In this specification, sideways does not mean merely horizontal but also downwards or upwards provided that sideways has the meaning of transversely of the general direction of light through the binoculars.

Any form of attachment of the camera to the binoculars can be used provided that the camera is roughly pointing in the right direction; any small error may result in some loss of field but little or no loss of image quality. If the binocular system has a flat field the light can be substantially perfectly collimated by the unit 10. Any departure from perfection will cause some loss of image quality but this might be acceptable.

The invention is not limited to the position of the reflex-type mirror, to those skilled in the art other locations and orientations may be preferable.

In use the camera would be fitted whenever the possible need for a photograph is sensed and the binoculars then used normally. When the photograph is to be taken the reflex-type mirror would be actuated and the camera shutter operated. Then the binoculars can be returned to normal use.

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C L A I M S

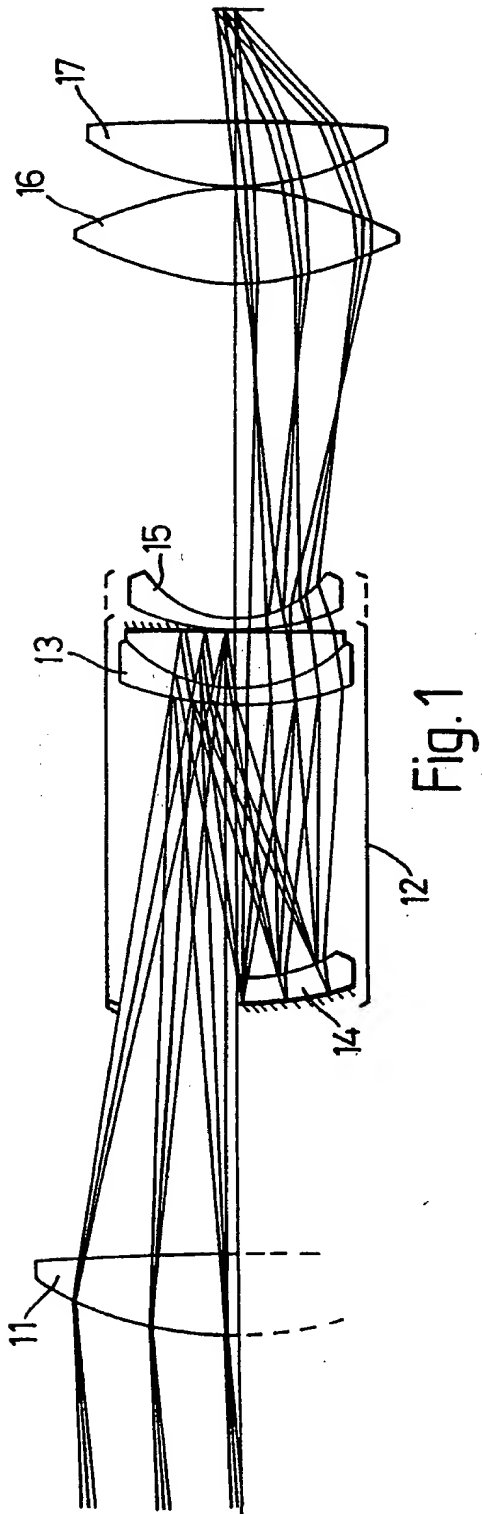
1. An optical system wherein a light path between an objective lens and an eyepiece includes a first and a second inverting mirror wherein the second inverting mirror
5 is disposed behind the objective lens and between that lens and the first inverting mirror.
2. An optical system according to claim 1 wherein the first and second mirrors have associated with them refracting elements and all optical corrections are made
10 in the mirrors and those refracting elements which being disposed where the light bundle is concentrated are of small size.
3. An optical system according to claim 1 or claim 2 wherein the first and/or second mirrors are of the Mangin-
15 type with the mirror formed by silvering a refracting element.
4. An optical system according to claim 1 or claim 2 wherein one or each mirror is a pure reflector disposed close behind a refracting element.
- 20 5. An optical system using inverting mirrors wherein the light paths are separated from each other by the use of polarising screens.
6. An optical system according to claim 5 having a polarising screen projecting into a light bundle passing
25 through an objective lens to intercept light that may bypass the desired path and a second polarising screen to intercept light having bypassed the desired path to eliminate such light and a retardation plate so that light passing through the first screen and following the desired
30 path will be able to pass through the second screen.

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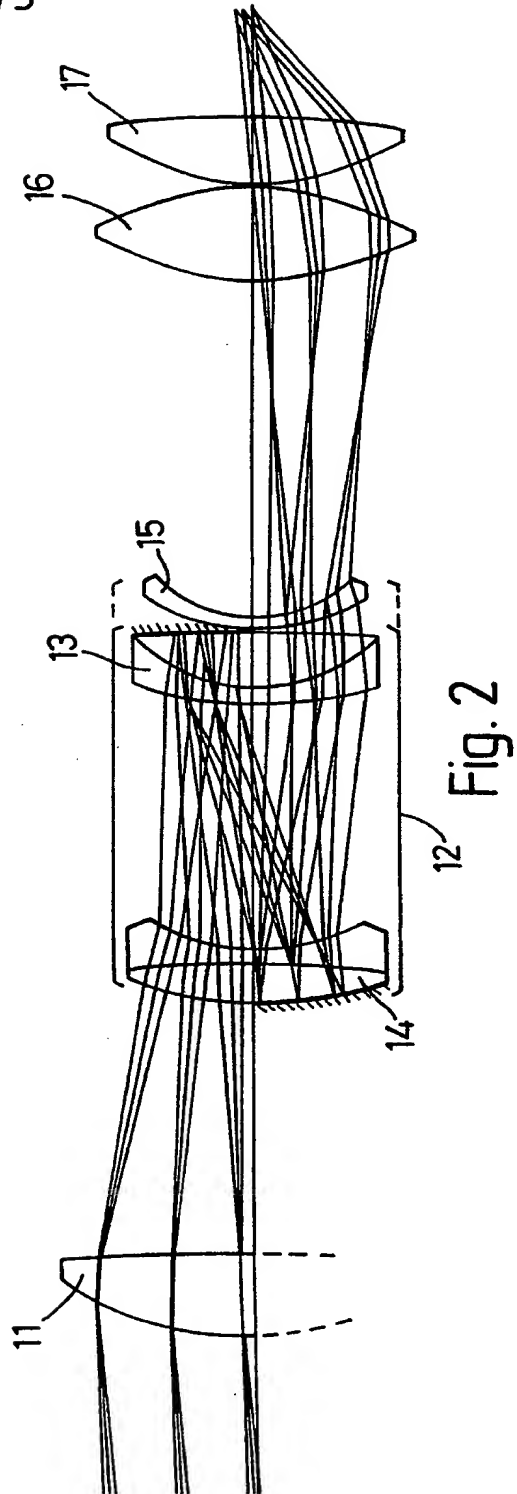
7. A binoculars-camera combination wherein the binoculars are provided with a reflex-type mirror towards the exit point of the binoculars, which mirror when actuated reflecting the light sideways,
5 and wherein the reflected light is substantially collimated either in the binoculars before reaching the said mirror or after reflection by said mirror, and wherein the camera is mounted out-of-line of the binoculars to receive the collimated light.

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2/3

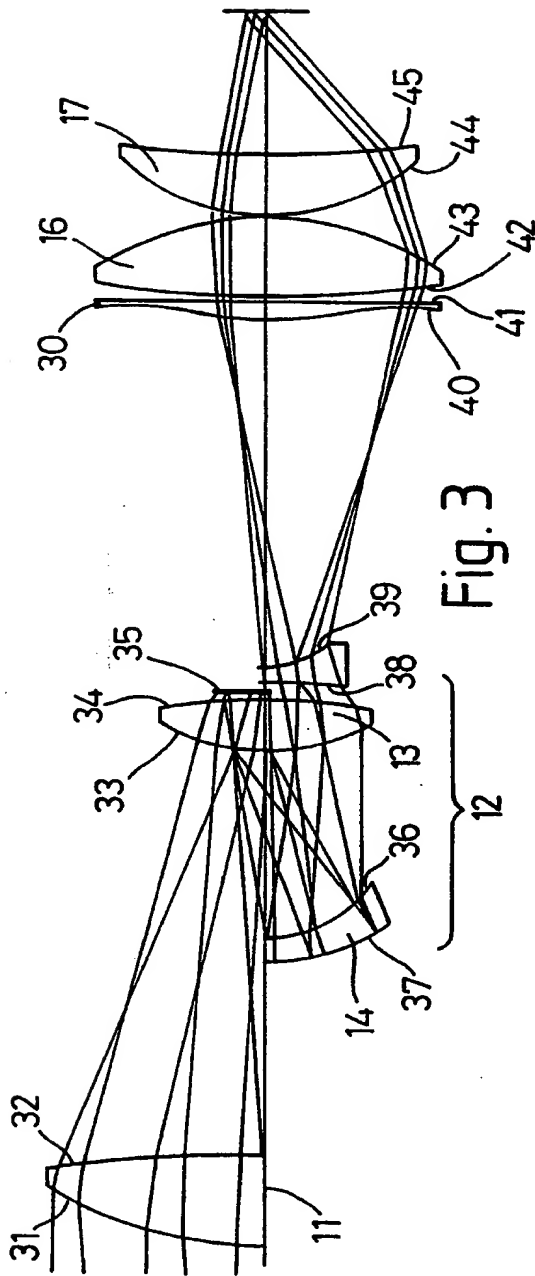


Fig. 3

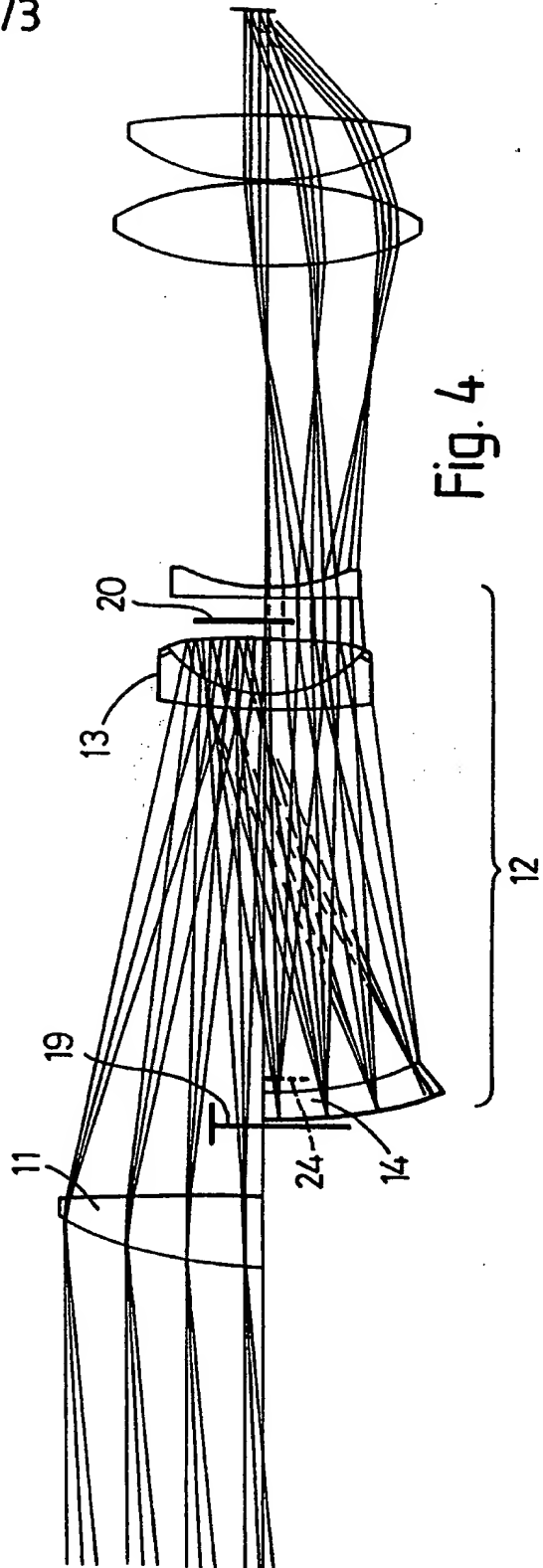


Fig. 4

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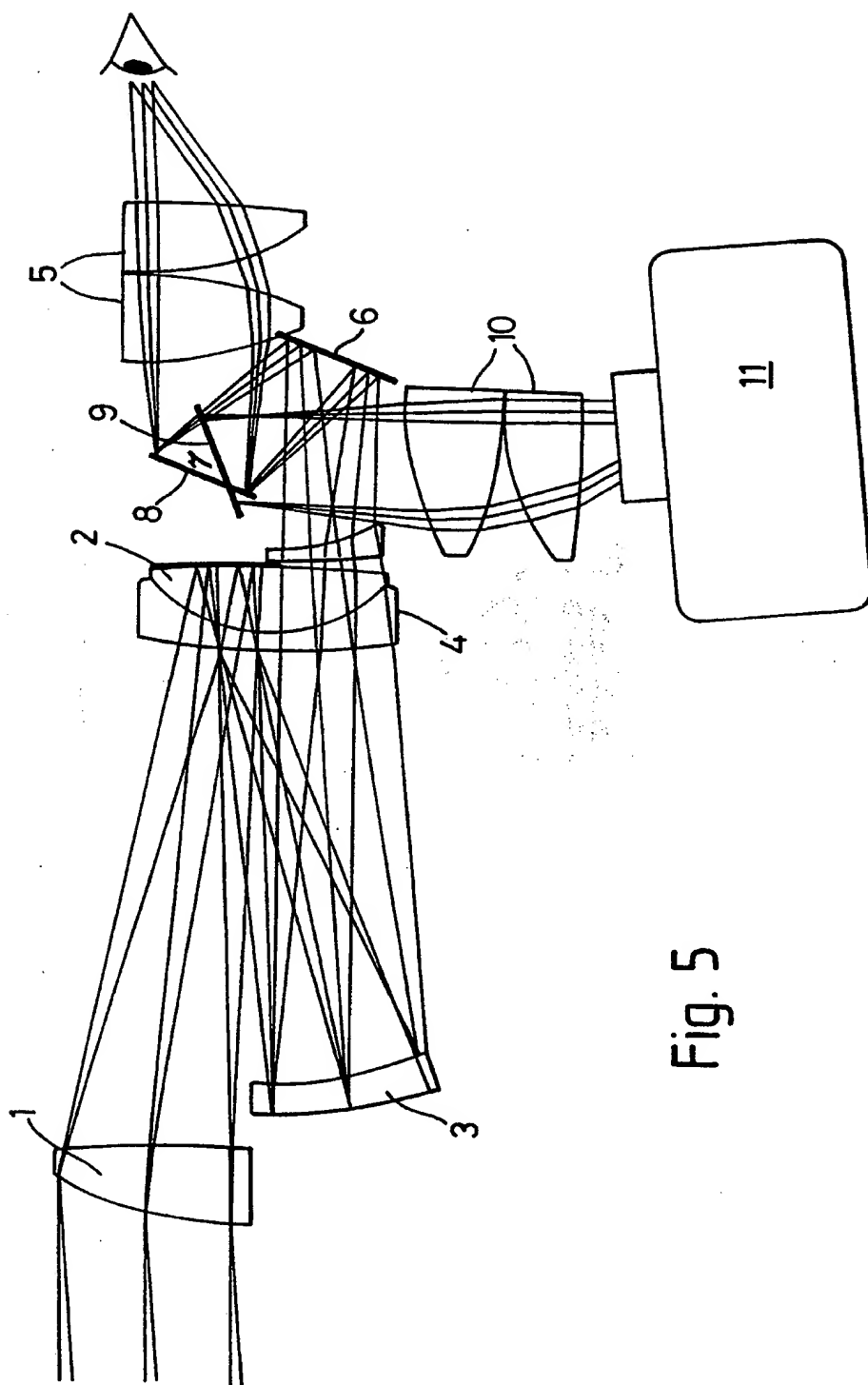


Fig. 5

INTERNATIONAL SEARCH REPORT

International Application No
PCT/EP 93/02297

A. CLASSIFICATION OF SUBJECT MATTER
IPC 5 G02B17/08 G02B23/02 G02B17/00

According to International Patent Classification (IPC) or to both national classification and IPC

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Minimum documentation searched (classification system followed by classification symbols)
IPC 5 G02B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category * | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|------------|---|-----------------------|
| A | WO,A,92 05462 (OPTICS AND VISION) 2 April 1992 cited in the application see claims; figures | 1-7 |
| A | EP,A,0 266 005 (PHILIPS NORDEN) 4 May 1988 see claims; figures | 1 |

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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Date of the actual completion of the international search

25 November 1993

Date of mailing of the international search report

08.12.93

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INTERNATIONAL SEARCH REPORT

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International Application No
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|---|---------------------|----------------------------|---------------------|
| WO-A-9205462 | 02-04-92 | AU-A- 8540491 | 15-04-92 |
| | | EP-A- 0550581 | 14-07-93 |
| | | GB-A- 2249406 | 06-05-92 |
| EP-A-0266005 | 04-05-88 | SE-B- 455237 | 27-06-88 |
| | | JP-A- 63141013 | 13-06-88 |
| | | SE-A- 8604590 | 29-04-88 |
| | | US-A- 4867547 | 19-09-89 |